Layered Random Beamforming OFDMA with Fair Scheduling Algorithms

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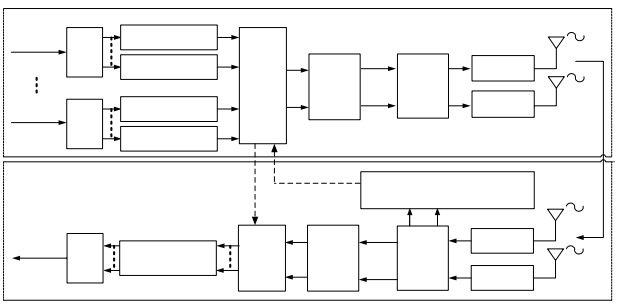
Introduction

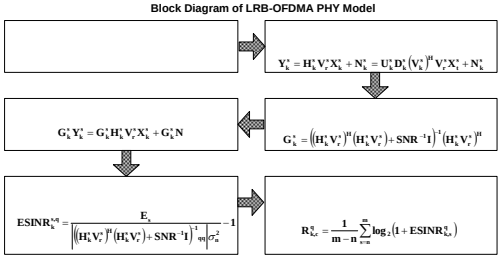
- **In a multi-user environment, combining MIMO layered random beamforming (LRB) technique and OFDMA is capable of achieving near maximal benefits from MIMO and multi-user diversity whilst requiring minimal feedback.**
- **3 dynamic scheduling algorithms are proposed for LRB-OFDMA and they show a trade-off between maintaining fairness and minimising delay.**

Physical Layer Model of LRB-OFDMA

- Low Feedback Compared to Eigenbeamforming: LRB-OFDMA only requires the feedback of ESINR based data rate from every cluster of sub-carriers of each spatial layer of MIMO channels.
- Multi-user Diversity Gain: Achieve spatial multiplexing gain, spatial multi-user diversity gain, layer spatial multi-user diversity gain and spectral multi-user diversity gain.



Block Diagram of LRB-OFDMA PHY Model



Reduced Feedback LRB-OFDMA System

PHY Parameters and Transmission Modes

Operating Frequency	5 GHz
Bandwidth	100 MHz
FFT Size	1024
Useful Sub-carriers	768
Guard Interval Length	176
Sub-carrier Spacing	97.656 KHz
Useful Symbol Duration	10.24 μs
Total Symbol Duration	12.00 μs

Parameters for the Proposed LRB-OFDMA

Mode	Modulation	Coding Rate	Coded Bits (subcarrier)	Max. Data Rate (R) Overall
1	BPSK	½	1	64 Mbps
2	QPSK	½	2	128 Mbps
3	QPSK	¾	2	192 Mbps
4	16 QAM	½	4	256 Mbps
5	16QAM	¾	4	384 Mbps
6	64 QAM	¾	6	576 Mbps

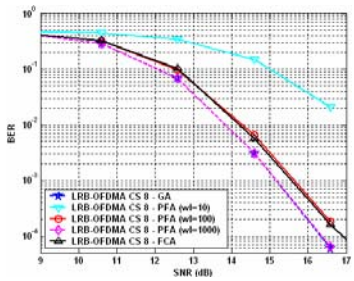
Transmission Modes and Data Rates

Performance of LRB-OFDMA in Statistical Channel

An uncorrelated MIMO implementation of the statistical channel model E of the ETSI BRAN channel models is used for system simulation. Channel model E have a sampling period of 10ns and the rms delay spread of 250ns.

Algorithms	CoV Across Different MSs	System Throughput
GA	0.4553	561.02 Mbps
PFA (wl=100)	0.4340	537.70 Mbps
PFA (wl=10)	0.3164	380.74 Mbps
FCA	0.0478	536.54 Mbps

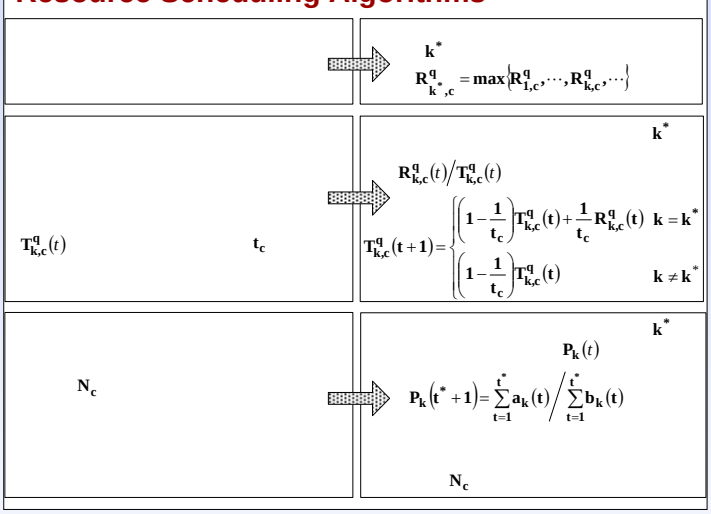
Overall System Throughput and CoV of Data Rate of LRB-OFDMA Employing Different Scheduling Algorithms Averaged Over 1000 Time Slots (Eb/No=12dB)



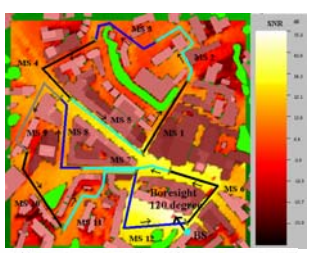
BER Performance of LRB-OFDMA Employing Different Scheduling Algorithms in a 12-MS Environment (Cluster Size=8)

- Adjusting window length of PFA shows in a trade off between throughput and fairness.
- The BER performance of FCA is very close to PFA with a high window length at 100 and FCA distributes the resources more fairly than PFA with a window length of 10.

Resource Scheduling Algorithms



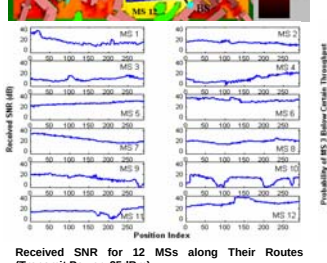
Performance of LRB-OFDMA in Ray Tracing Channel



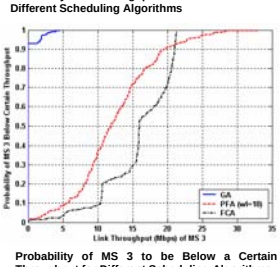
A 12-MSs outdoor environment (Bristol city-centre, U.K.) is considered for simulation (2x2 MIMO channels) and each MS moves along a pre-defined and independent route.

Algorithms	Log Fairness Metric	System Throughput
GA	9.27	405.17 Mbps
PFA (wl=10)	14.77	263.10 Mbps
FCA	15.32	299.31 Mbps

Overall System Throughput and Level of Fairness of LRB-OFDMA Employing Different Scheduling Algorithms



Received SNR for 12 MSs along Their Routes (Transmit Power=25dBm)

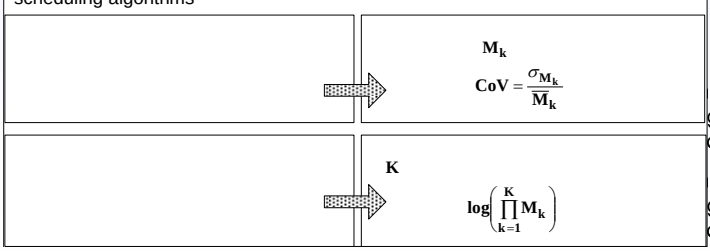


Probability of MS 3 to be Below a Certain Throughput for Different Scheduling Algorithms

Mobile Station 3:
GA: no signal at more than 90%.
PFA (wl=10): 5Mbps at more than 90% of the locations.
FCA: 10 Mbps at more than 90% of the locations.

Fairness Metric

Two fairness metrics are adopted for fairness performance evaluation of different scheduling algorithms



Conclusions

- **A greedy algorithm, a proportional fair algorithm and a fair cluster algorithm considered for LRB-OFDMA are shown to have increasing fairness.**
- **For PFA, increasing the window length improves the overall throughput performance but degrades the fairness.**
- **The FCA achieves a good balance between the overall throughput and both short and long term fairness. However, overall throughput may be degraded while maintaining a fair resource allocation as the difference in fading statistics of MSs becomes more significant.**

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